EFFECTS OF SURFACE ROUGHNESS USING DIFFERENT ELECTRODES ON ELECTRICAL DISCHARGE MACHINING (EDM)

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A project report submitted in partial fulfillment
of the requirements for the award of the degree of
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

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STUDENT DECLARATION

I declare that this thesis entitled effects of surface roughness using different electrodes on electrical discharge machining (EDM) is the result of my own project except as cited in references. The thesis has not accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Dedicated to my beloved

“family“

For their endless support in term of motivation,

supportive and caring as well throughout the whole project

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ABSTRACT

The electrical discharge machining (EDM), is one of the processing based on non-traditional manufacturing procedures, is gaining increased popularity, since it does not require cutting tools and allows machining involving hard, brittle, thin and complex geometry. The objective of the project is to predict the surface roughness on the workpiece using different electrode such copper, aluminum and brass. There must be a different on surface roughness produce in tool steel workpiece. Results obtained from this study will be compared among each other and similar studies in the literature. The problem of this project is to predict the best electrode among copper, brass and aluminum electros that can give the smoothes surface roughness on the tool steel workpiece. The problem face in this project is to choose and set the parameters before running the experiment. The EDM parameters such as current, pulse on-time, pulse off-time, arc voltage, also can affect the R_a, surface roughness on the workpiece. This is because the parameters are different between the electrodes each electrode has their own characteristics. The tool steel workpiece is machined by EDM using copper, brass, and aluminum electrodes. After machining, the workpiece will be measured using perthometer. Data collected will be analyzed before deciding the best electrode. The best electrode for the EDM between copper, aluminum, and brass is copper electrodes.

ABSTRAK

Electrical discharge machining (EDM) adalah salah satu cara memproses berdasarkan prosedur bukan tradisional. Electrical discharge machining tidak memerlukan mata alat dan membenarkan memproses bahan-bahan kuat, rapuh dan mempunyai bentuk yang compleks. Projek ini adalah bertujuan untuk meramalkan kekasaran permukaan pada bahan dengan mengunakan electrode yang berbeza seperti copper aluminium dan brass. Keputusan yang diperolehi daripada experiment ini akan dibandingkan antara satu sama lain untuk menentukan electrode mana adalah yang terbaik. Permasalahan projek ini adalah untuk menentukan menentukan electrode terbaik yang akan digunakan dalam EDM dan akan memberikan permukaan paling licin pada bahan yang dimesin. Masalah yang dihadapi dalam projek ini adalah untuk menentukan parameter pada EDM seblum menjalankan experimen. Parameter EDM seperti current, pulse on-time, pulse off-time, arc voltage boleh memberi kesan kepada permukan bahan. Ini kerana setiap electrode yang berbeza mempunyai karekter yang berbeza. EDM akan memesin bahan mengunakan electrode copper, brass dan aluminium dan setelah selesai, sampel akan diukur dengan menggunakan perthometer. Data akan dianalisis sebelum menentukan electrode mana adalah terbaik. Berdasarkan experiment ini electrode copper adalah electrode terbaik bebanding aluminium dan brass.

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ABBREVIATION	MEANING
EDM	Electrical discharge machining
RMS	Root means square
R_q	Root means square
L	Evaluation length
Z	Height
X	Distance along measurement
AA	Arithmetic average
CLA	Center-line average
R_a	Average roughness

CHAPTER 1

INTRODUCTION

1.1 Project title

The title of the project is the effects of surface roughness using different electrodes on electrical discharge machining (EDM).

1.2 Project background

This project background is to predict the effect on the surface roughness on electrical discharge machining (EDM) by using different type of electrodes.

The EDM machining process is a thermal process that involves melting and vaporisation of the workpiece electrode. In this machining process, it uses an electrical discharge to remove material from the workpiece, each spark jump from the electrode to the work piece and its cause the material to be removed from the workpiece. This is how the machining process works in the EDM. The knowledge about the EDM is required before running the process.

The objective of the project is to predict which material of the electrodes will give the best surface roughness on the tool steel workpiece either aluminum, copper or brass.

Another equipment use in the project is perthometer. It is use in this project to measure the surface roughness on each sample machined by each electrode. All the data will be collect and will be analyze.

1.3 Problem statement

The problem of this project is to predict the surface roughness on the tool steel workpiece using different type of the tool in the EDM machining and choosing wrong material will affect the surface on the workpiece. It is because each type of tool has its own characteristic such as conductivity and the strength of the tool. The application of this experiment is to predict which electrode is the best of machining the cavity on the mold. Some of the product that want to be produce by injection molding need very smooth surface.

In the EDM machine, the parameter will affect the surface roughness on the tool steel workpiece is the EDM machine parameter itself. There are two type of the parameter on the EDM machine; it is non electrical and electrical parameter. Electrical parameter may affect the surface roughness is pulsed current and pulse time, higher or lower values of these parameters may decrease or increased the surface roughness on the tool steel workpiece. Each value of this parameter in the process will ensure that the surface roughness produce on the tool steel will be in an acceptable range or not.

1.4 Objective of the project

The objective for this project is to investigate which tool among the aluminum, brass and copper can give the best surface roughness on the tool steel workpiece using EDM machine. The best value is of the surface roughness is 0.35µm.

1.5 Scope of project

The scope of the project is to focus on the investigation of surface roughness on the tool steel workpiece using different types of electrode. The electrodes used is copper, brass and aluminum.

1.6 Thesis organization

Chapter 1: Introduction

In this chapter, its elaborate the main idea of the project and it is including the title of the project, objective of the project, problem statement, scope of the project and the project background. This chapter briefly explains about the guidance and information of the project.

Chapter 2: Literature review

This chapter elaborate the meaning and the information of the project where its inform the detail about the project and where the ideas, data and information of the project area collect from various article and journal as a reference in order to understand the concept of the project.

This chapter includes the introduction of the surface roughness in the EDM machining, the parameter affecting the surface roughness on the workpiece. This chapter also discusses about the machine itself or in other word what is the EDM machine all about and what are the electrical and non electrical parameter in this machine. It also includes the briefly explanation of the parameter in this machine.

This chapter is very important in order to understand the parameter of the EDM and the tool that lead to the better surface roughness on the workpiece. The information and knowledge gain in this chapter advanced to elaborate to the next chapter.

Chapter 3; Research methodology

This chapter discuss on the method that will be use in this project. All the quantity, equipment, method and machine which use in this project will be inform and list in this chapter. The step of the experiment on surface roughness using different electrodes is design before the experiment run.

Chapter 4; result and discussion

In this chapter, all the result generates from the experiment will be analyze. The result of the experiment is evaluated and discussed to know what have been learned.

Chapter 5; Conclusion

These chapters are concluded and decide which material will give the surface roughness. This chapter also concludes if the project is successful and the result is the same as the previous result done as state in the journal and article.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

EDM is no longer a "non-conventional" machining method. It is claimed that EDM is now the fourth most popular machining method, leading behind milling, turning and grinding. One of the major reasons for the turnaround is that in today's context, EDM machines have dramatically increased their cutting speeds, surface finishes and accuracies with unattended operations. As a result, the sale of these machines has increased dramatically with the growth of EDM technologies.

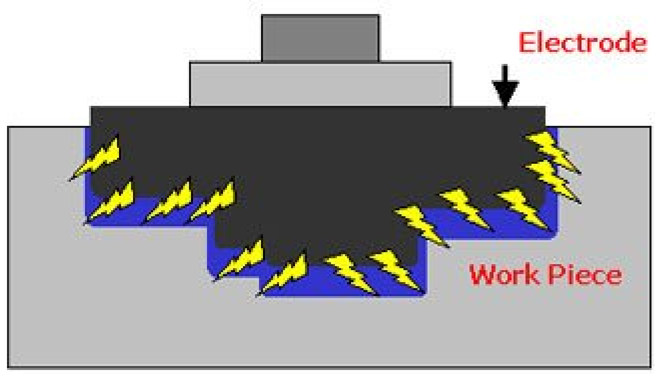

Figure 1: EDM process on workpiece

In this process, the desired shape is formed when sparks jump from the electrode to the work piece and cause material to be removed from the workpiece. Ram EDM is generally used to produce the blind cavities such as Mobile phone cavities, Speaker grill cavities etc [1].

2.2 Fundamental principles of EDM and surface roughness

One of the most important features of the EDM method is its ability to work independently of the mechanical properties of the machined material. Once voltage is applied to the electrode and the work piece, electrons detached from the electrode (cathode) move accelerated towards the work piece. At the destination, they hit neutral dielectric molecules, removing more electrons. These electrons, in turn, accelerate the electron flow towards the anode by similar collisions. This motion of electrons creates a leakage current in the dielectric, evaporating the dielectric fluid in this region. The current increases in the evaporating fluid. At the end, a “plasma” channel is created between the electrode and the work piece. Due to its high temperature, this channel melts or evaporates a “crater” on both the work piece and the electrode. After the plasma channel extinguishes, all of the evaporated and a part of the melted material is flushed away by the flow of dielectric fluid. A small “crater” is created on the surface of the electrode and the work piece. Craters created by a multitude of plasma channels allow the surface machining [7].

2.3 Electro discharge machining process

Electro discharge machining (EDM) is a thermo-electrical material removal process, in which the tool electrode shape is reproduced mirror wise into a work material, with the shape of the electrode defining the area in which the spark erosion will occur. The machine tool holds a shaped electrode, which advances into the work material and produces a high frequency series of electrical spark discharges. The sparks are generated by a pulse generator, between the tool electrode and the work material, submerged in a liquid dielectric, leading to metal removal from the work material by thermal erosion or vaporization. Melting and vaporization of the work material dominates the material removal process in EDM, leaving tiny craters on the surface of the work material. EDM has no contact and no cutting force process, and therefore does not makes direct contact between tool electrode and the work material.

This eliminates the chances of mechanical stress, chatter and vibration problems, as is prominent in traditional machining [13].

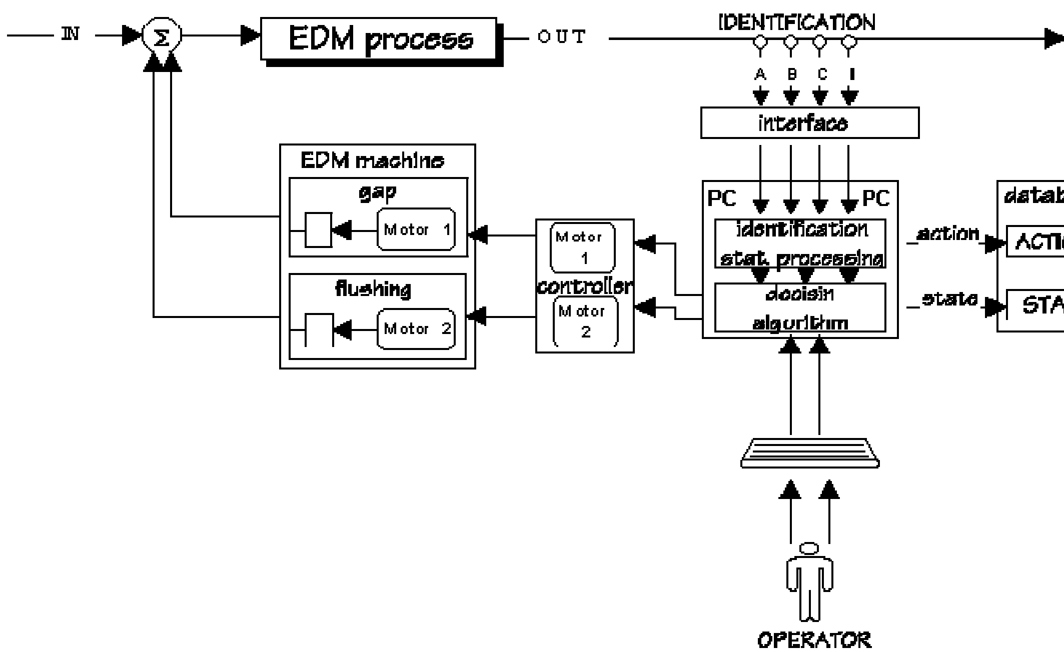

Figure2: Adaptive control system for EDM process control

2.4 Literature survey on surface roughness

2.4.1 Surface roughness (surface quality)

Surface roughness is harder to attain and track than physical dimensions are, because relatively many factors affect surface roughness. Some of these factors can be controlled and some cannot. Controllable process parameters include feed, cutting speed, tool geometry, and tool setup. Other factors, such as tool, workpiece and machine vibration, tool wear and degradation and workpiece and tool material variability cannot be controlled as easily [3].

The closed-form solutions of surface roughness parameters for a theoretical profile consisting of elliptical arcs are presented. Parabolic and simplified approximation methods are commonly used to estimate the surface roughness parameters for such machined surface profiles. The closed-form solution presented in this study reveals the range of errors of approximation methods for any elliptical arc size. Using both implicit and parametric methods, the closed-form solutions of three surface roughness parameters, Peak-to-Valley Roughness, Rt, Arithmetic Average Roughness Ra, and Root-Mean-Square Roughness Rq, were derived [6].

In other work surface roughness or surface quality, also known as surface texture are terms used to describe the general quality of machined surface, which is concerned with the geometric irregularities and the quality of a surface. The ideal surface roughness may be specified in various ways, but two common methods are the peak to valley height (h) and the arithmetic average, Ra (µm). The Ra value, also known as centre line average (CLA) and arithmetic average (AA) is obtained by averaging the height of the surface above and below the centre line [11].

In EDM process, the surface produced consists of a large number of craters that are formed from the discharge energy. The roughness of surface mainly depends upon the energy per spark. If the energy content is high, deeper craters will be attained, leading to poor surface. The surface roughness has also been found to be inversely proportional to the frequency of discharge. Assuming that each spark leads to a spherical crater formation on the surface of workpiece, the volume of metal removed per crater will be proportional to the cube of the crater depth [10].

2.4.2 Root mean square (RMS)

RMS roughness was defined as follows: [3], [4]

$$R_q = \sqrt{\frac{1}{L}\int_0^L Z^2\,(x)dx} \qquad \text{(Eq 2)}$$

Where,

L = evaluation length

z = height

x = distance along measurement

2.4.3 AA (arithmetic average) or center-line average (CLA) roughness

AA (arithmetic average) or center-line average (CLA) roughness: [3], [4].

$$R_a = \frac{1}{L}\int_0^L |z(x)|\,dx \qquad \text{(Eq 2.1)}$$

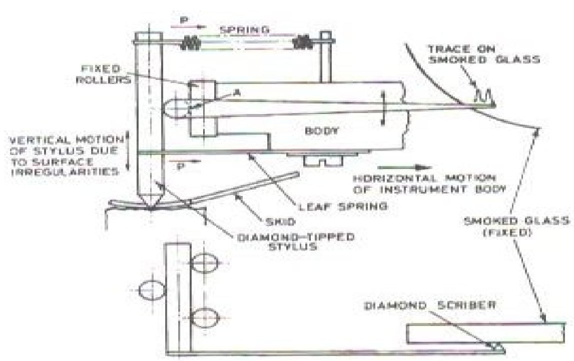

Figure 3: Tomlinson Roughness Meter [3]

Result of EDM done by copper electrode [7]

Table 3 – Results of the EDM experiment done by copper electrodes

I (A)	t_{on} (μs)	t_{off} (μs)	V (V)	R_a (μm)	I (A)	t_{on} (μs)	t_{off} (μs)	V (V)	R_a (μm)	I (A)	t_{on} (μs)	t_{off} (μs)	V (V)	R_a (μm)
7	6	12	40	1.7	7	12	25	40	1.68	12	12	12	100	2.85
7	12	12	40	1.85	7	25	25	40	1.93	12	25	12	100	3.2
7	25	12	40	2.14	7	50	25	40	2.28	12	100	12	100	4.03
7	50	12	40	2.43	7	100	25	40	2.68	22	6	12	40	2.76
7	100	12	40	2.64	7	12	25	60	1.85	22	12	12	40	3.31
7	12	12	60	1.94	7	25	25	60	2.1	22	50	12	40	4.65
7	25	12	60	2.4	12	100	25	60	3.77	22	100	12	40	4.8
7	100	12	60	2.9	12	6	25	80	2.12	22	6	12	60	3.06
7	6	12	80	1.9	12	12	25	80	2.46	22	12	12	60	3.61
7	12	12	80	2.1	12	50	25	80	3.21	22	50	12	60	4.8
7	50	12	80	2.69	12	100	25	80	3.82	42	50	12	40	5.6
12	12	12	80	2.67	12	6	25	100	2.26	42	100	12	40	5.83
12	25	12	80	2.88	12	12	25	100	2.63	42	12	12	60	4.5
12	50	12	80	3.3	12	25	25	100	2.77	42	25	12	60	5.14
12	1	12	80	3.96	12	100	25	100	3.94	42	50	12	60	5.73
12	12	12	100	2.85	22	6	25	40	2.7	7	100	12	80	3.0
12	25	12	100	3.2	22	12	25	40	3.15	7	6	12	100	2.0
42	12	25	60	4.43	22	100	50	40	4.3	22	12	100	40	2.86
42	50	25	60	5.56	22	12	50	60	3.26	22	50	100	40	3.6
⋮														
42	100	25	60	5.9	22	25	50	60	3.53	22	100	100	40	4.0
42	6	25	80	4.33	22	50	50	60	3.86	22	12	100	60	3.1
7	50	25	80	2.41	22	12	50	100	3.58	22	100	100	80	4.23
7	100	25	80	2.92	42	25	50	60	4.46	22	6	100	100	3.03
7	6	25	100	1.7	42	50	50	60	4.91	22	12	100	100	3.39
7	12	25	100	1.96	42	100	50	60	5.64	22	50	100	100	3.9
7	25	25	100	2.14	42	12	50	80	4.48	22	100	100	100	4.43
7	100	25	100	3.05	42	25	50	80	4.7	42	6	100	40	3.61
12	6	25	40	2.01	42	50	50	80	4.97	42	12	100	40	3.76
12	12	25	40	2.16	42	100	50	80	5.72	42	25	100	40	3.96
7	25	100	40	1.79	42	100	100	80	5.01	7	100	50	100	2.97
7	100	100	40	2.35	42	12	100	100	4.45	12	6	50	40	1.8
7	6	100	60	1.4	42	25	100	100	4.65	12	25	50	40	2.26
7	12	100	60	1.67	42	100	100	100	5.16	12	50	50	40	2.6
7	50	100	60	2.2	12	100	50	40	3.24	12	6	50	60	1.98
7	100	100	60	2.42	22	6	50	80	2.9	22	100	12	60	5.29
7	6	100	80	1.44	22	25	50	100	3.87	22	6	12	80	3.23
7	12	100	80	1.74	22	50	50	100	4.3	22	12	12	80	3.61
7	25	100	80	2.14	22	100	50	100	4.87	22	25	12	80	4.34
7	50	100	80	2.32	42	12	50	40	4.06	22	100	12	80	5.53
42	25	50	40	4.41	42	60	12	40	4.1	22	6	12	100	3.4
42	50	50	40	4.78	42	12	12	40	4.2	22	25	12	100	4.67
42	100	50	40	5.3	22	100	12	100	5.9					
42	6	50	60	3.93	22	50	12	100	5.12					

Figure 4: Table of Result done by copper electrode

2.5 Machining Parameter Selection

In the EDM, the variables parameters are have great effects to the machining performances results especially to the material removal rate (MRR), electrode wear rate and surface quality. There are two major groups of parameters that have been discovered and categorized [2]:

1) Non-electrical Parameters
    a. Injection flushing pressure
    b. Rotational of speed electrode

2) Electrical Parameters

a. Peak current
b. Polarity
c. Pulse duration
d. Power supply voltage

It was observed that surface roughness of workpiece and electrode were influenced by pulsed current and pulse time, higher values of these parameters increased surface roughness. Lower current, lower pulse time and relatively higher pulse pause time produced a better surface finish.[5] To determine the most optimum material removal time, it should be ensured that the surface roughness stays within an acceptable range [7].

Another performance indicator of the EDM process is the roughness formed on the surface of the work piece. One of the areas among studies involving the EDM most researches have been made on is the effort to decrease the surface roughness. While depending on the machining parameters during the EDM, the surface roughness is also greatly affected by the material properties of the workpiece and the electrode [7].

2.6 Basic parameters affecting the manufacture process

1) Discharge current (*I*): value of the current applied to the electrode during pulse on-time in the EDM. Discharge current is one of the primary input parameters of an EDM process and together with discharge duration and relatively constant voltage for given tool and work piece materials
2) Gap voltage (V): voltage applied between the electrode and the work piece during the EDM.